SEMINAR ON:

URBAN DRAINAGE MANAGEMENT

May 18, 1983

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POLLUTION CONTROL ASSOCIATION OF ONTARIO
and the
ONTARIO MINISTRY OF THE ENVIRONMENT

PROCEEDINGS
of the
SEMINAR
on
URBAN DRAINAGE MANAGEMENT

Ontario Ministry of Health Laboratories
Resources Road, Toronto

MAY 18, 1983

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Ministry of the Environment

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ONTARIO URBAN DRAINAGE MANAGEMENT PROGRAM

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ONTARIO URBAN DRAINAGE MANAGEMENT PROGRAM

The Urban Drainage Management Program in Ontario was initiated in 1973. This program is presently on-going and covers all aspects related to control of urban runoff including combined sewer overflows, and with main activities ranging from problem definitions, control technologies evaluation to policy development. Multiple agencies from all levels of Government, conservation authorities, technical interest and land development industry groups are involved. A policy implementation package is now at the final stage of preparation.

This paper briefly describes all phases of the Program up to the present time with particular emphasis on the policy development. The presentation is structured in the following format:

- Review of urban drainage problems.
- Research and development efforts over the past decade to tackle these problems. Results of these efforts have been consolidated into policy formulation.
- Policy development activities.
- Present status on the Policy development.

In addition, some predictions about the future trend in urban drainage management in Ontario will be discussed. To round off the presentation, the U.S. Nation-wide Urban Runoff Program will be briefly described. This program (NURP) represents a fairly concentrated research effort in stormwater quality management, and some of its results are of interest to us.

1. URBAN DRAINAGE PROBLEMS

Urban drainage problems can be described under two categories - those associated with water quantity and those pertaining to water quality. Quite often these problems are inter-related.

1.1 Water Quantity Problems

Urbanization, and accompanying storm sewer servicing, increases both the volume and rate of runoff from rainfall events. Urban development converts pervious soil cover to impervious roads, parking lot and roof tops. The proportion of rainfall that runs off following urbanization increases typically from 10% to 40-50% of the total water budget (Figure 1). The rate at which the water runs off as well as the peak flow is increased by the provision of improved drainage systems (Figure 2).

The increased flood flows result in a need for larger bridges and culvert facilities, and downstream channel modifications. Channel erosion is increased as the more frequently occurring higher velocity floods cut a larger channel and cause property damage and loss of recreational land as banks collapse. Sediment pollution is also caused by this erosion. Redeposition of sediment further downstream will aggravate flooding and increase the size of flood plain areas, putting more structures under flood risk and/or removing land from development potential.

Increased land imperviousness allows less opportunity for water to infiltrate into the soil and generally results in reduced levels in groundwater, reduced flow in rivers; thus potentially aggravating water quality problems, altering vegetation and wildlife habitat, and reducing recreational potential.

Conventional municipal drainage systems have storm sewers typically designed for storms with return periods of 2 to 5 years. When there is more storm runoff than the storm sewers can handle, problems occur, ranging from minor inconveniences from surface ponding to serious structural damange to homes and basements from flooding. These problems are caused largely from the inadequate design for managing runoff when "major" systems were installed.

1.2 Water Quality Problems

Many different pollutants wash off urban land surfaces during rainstorms and contribute to the degradation of receiving water bodies. Pollutants in the runoff include salts, pesticides, fertilizers and other chemicals as well as sediment, litter and the debris which accumulate in most urban areas. Bacteria, animal parasites and viruses are present from pet feces and bird droppings. Chemical spills in industrial and commercial areas easily make their way to surface waters in the drainage systems. Oils and grease and other petroleum products from car maintenance are commonly found in urban runoff along with PCBs, heavy metals, especially lead, zinc, copper, cadmium and traces of mercury.

Older Ontario cities were originally provided with combined sewers to carry sanitary and industrial wastes, as well as surface runoff during rainfall events. These combined sewer systems are designed with a sanitary sewer interceptor which conveys dry weather sewage flows to the municipal sewage treatment plant, and which has a limited capacity to carry wet weather flows. The excess which overflows contains urban runoff pollutants, as described above, as well as sanitary sewage including human fecal matter and industrial discharges. These overflows to surface waters cause water quality degradation, and are a potential health hazard to swimmers and water intakes, and result in impaired aesthetics from offensive floating solids and debris, and may adversely affect fish and other aquatic organisms.

During the construction phase of urban development, eroded sediment during runoff events may increase by as much as one thousand times compared to pre-development conditions. The sediment represents a loss of valuable top soil which may be redeposited in reservoirs or lower reaches of rivers, decreasing storage and flow capacities. The sediment may also be deposited in fish spawning beds with potential impairment to valuable fishery resources. Many pollutants are associated with sediments and contribute to general water quality degradation.

2. RESEARCH AND DEVELOPMENT PROGRAMS

Faced with these urban drainage problems, the Ontario Government, in co-operation with the Federal Government and municipalities mounted extensive efforts over the past decade to determine the magnitude of these problems and their effects as well as to provide solutions. The research efforts can largely be grouped under two major Programs. The first Program was conducted under the auspices of the Canada-Ontario Agreement on Great Lake Water Quality - Urban Drainage Committee (1). Projects under the Program were aimed mainly at refined problem characterizations and control technologies development and evaluation. Total cost of the Program was in excess of $2 million. The second Program, named "Pollution from Land Use Activities in the Great Lakes Study", was conducted jointly with the U.S. agencies and under the auspices of the International Joint Commission (2). Projects under this Study mainly consisted of on-land and in-stream monitoring to define pollution loadings from various sources (e.g. municipal, industrial, agricultural, silvicultural discharges and atmospheric deposition, etc.)

and to determine which of these pollution sources were significant contributors to water quality problems in the Great Lakes areas. Total cost of the Study was in excess of $11 million.

Besides these concentrated programs which ended at the beginning of the 80's, federal and provincial research efforts are on-going, principally in the areas of hazardous contaminants problem characterization, computer models refinement and technologies evaluations (3).

2.1 Research Program Conclusions

Vast amount of data and information generated from the above programs can be summarized into the following major conclusions:

o Quantity control of stormwater is generally needed in urbanized areas to protect public health and property damages from flooding. The most effective way to deal with stormwater management is to use a combination of advance planning and effective control practices. Both modern planning techniques and innovative control technologies and designs have been developed and field tested. In a lot of cases, these innovative practices can be more cost-effective than conventional ones.

o In general, on a lake-wide basis, pollution from urban drainage does not have a major impact on water quality. For example, it has been estimated that approximately 3-5% of the total phosphorus loadings to the Great Lakes comes from stormwater.

Although a larger portion of the loadings of some persistent toxic organics (e.g. PCBs) and heavy metals (e.g. lead) to the Great Lakes are believed to be coming from urban sources, their exact proportion relative to other point sources and atmospheric inputs, as well as their significance to the environmental impact have yet to be determined. As concentrations biomagnify through food chain route, there is concern over the long-term accumulation of these persistent substances in the ecosystem and their potential adverse human health effects. Needless to say that more research should be carried out in these vital areas. Solids have been found to be a very effective medium for transport of trace metals in urban runoff. Thus the removal of solids could be a significant measure in the reduction of trace metals and certain toxic oganics.

At this stage, across-the-board quality control of urban drainage is not recommended. except to reduce erosion and control sediments during construction. Most of the sediments from urban sources come from land disturbing activities during land development. Sediment control measures during construction have been well developed and are considered to be cost-effective, particularly the "good housekeeping" type practices. Consequently, this type of control should be implemented on an across-the-board basis.

In site-specific cases, such as large urban areas draining to sensitive receivers or to near-shore embayment areas or public beaches on the Great Lakes, contribution from urban runoff can be significant. Under these conditions, each case has to be evaluated separately, and an overall pollution control strategy formulated to prescribe the best combination of measures to control all sources (which could include urban runoff control) to meet local water quality criteria.

3. POLICY DEVELOPMENT ACTIVITIES

Findings from the research and development programs were consolidated and used as a basis to develop policies. The policy development activities in Ontario involved two steps:

- o Between 1978-80, an inter-agency Urban Drainage Policy Committee developed the five policy statements for effective and efficient control of the quantity and quality of urban drainage. The document was published as "Proposed Model Policies for Urban Drainage Management"(4) under the Canada-Ontario Agreement on Great Lakes Water Quality.
- o Towards the end of 1980, the Urban Drainage Policy Implementation Committee was formed to adopt the Model Policies for Ontario use, to develop a policy implementation strategy as well as the necessary technical guidelines to support policy implementation. Representatives from Ministries of Environment, Municipal Affairs and Housing, Natural Resources and Transportation and Communications, and from the Municipal Engineers' Association and Conservation Authorities Association sit on the Committee.

3.1 Policy Description

The purpose of the Urban Drainage policies is to enable the uniform application of innovative and sound stormwater management practices in the most cost effective manner. This is done in accordance with the five policy statements - three of them encourage good planning and two of them encourage good practices. These policies are heavily oriented towards new land developments because the planning and design stages of development is the best time to implement cost effective control measures. The five statements are:

"Good Planning" Policies

i) Master Drainage Plan: Municipalities should prepare Master Drainage Plans for developing areas within their boundaries to ensure that drainage systems are developed in a manner compatible with watershed needs, to identify existing water quality, flooding and channel erosion problems and to devise control schemes to solve these problems as well as to avoid future problems.

ii) Stormwater Management Plan: As part of the review process for plans of development (draft plan of subdivision), proponents should indicate (in a Stormwater Management Plan) the predicted effects of the development on the water resources, and the measures proposed to prevent adverse effects.

iii) Pollution Control Strategy: Municipalities with pollution problems from multiple sources should develop a comprehensive strategy to control pollution sources within the municipal boundaries. Dry weather sources such as sewage treatment plant effluent plus wet weather sources such as combined sewer overflows and storm drainage should be considered.

"Good Practice" Policies

iv) Major and Minor Drainage Design: New drainage systems for all developments should be designed using the major-minor system concept which recognizes the dual role of the drainage system in providing for convenience during minor (frequent) runoff events and protect life and minimize property damage during major (rare) runoff events.

v) Erosion and Sediment Control: Proponents of new urban development should plan for and carry out an erosion and sediment control program in the planning and construction stages of development, and to follow this up with an adequate maintenance program.

3.2 Proposed Policy Implementation Strategy

Master Drainage Plan and Stormwater Management Plan are considered the best means for recognizing watershed constraints and providing drainage control measures accordingly. This urban drainage planning process should be integrated with the normal land development process at an early stage.

The sequence and interrelationship of plans is shown in Figure 3. Master Drainage Plan (MDP) should be prepared at the Secondary or Neighbourhood Planning stage for a large development. Ideally, it will receive input from Watershed Plan and Pollution Control Strategy and produce an optimal "drainage control scheme" consistent with the overall land use pattern set out in the Secondary Plan. This overall "drainage control scheme" will then be used to guide the preparation of Stormwater Management Plan (SWMP) at draft plan stage for a subdivision; so that the optimal "drainage design" (in SWMP) will integrate drainage controls with detailed land use requirements, and will meet the criteria set out in the "drainage control scheme" (in MDP). Major/Minor Drainage Systems concept and Erosion and Sediment Control Practice will be incorporated into the design in SWMP.

To provide some idea about the scale and details of these plans, an hypothetical example is given. Figure 4a shows that a large area, say 300 hectares, in the watershed is under development. MDP (Figure 4b) will take into account watershed constraints and produce a "drainage control scheme" which typically contains: allowable runoff rates from different areas of the development, various routes of flow, decision on the use of on-line or off-line storage or direct discharge, area of storage required and approximate locations, treatment of stormwater (if required on site-specific cases as determined through Pollution Control Strategy; refer to Sections 3.3). So now, if a developer wants to build in a particular subdivision (as shown in Figure 5a), he knows exactly what has to be done on drainage control. Accordingly, the criteria in the MDP are translated into drainage design details in the SWMP (Figure 5b), and this is to be integrated with land use layout to optimize the control design. From this, more details can be added as shown in Figure 6.

It is recognized that the most effective way to develop the hierarchy of plans is to start with a Watershed Plan followed by the Master Drainage Plan and lastly a Stormwater Management Plan. Each succeeding level of plan is simplified by the existence of the higher level plan. However, development pressures may not permit such an ideal sequence of plan making. Consequently a flexible approach should be adopted in the absence of the higher level plans. For example. the Stormwater Management Plan may be expanded to include identification of watershed constraints and drainage controls.

3.3 Pollution Control Strategy (PCS) and its Relationship with Urban Drainage Plans

The overall goal of the Ministry of the Environment's surface water quality management program is to ensure that the surface waters of the Province are of a quality which is satisfactory for aquatic life and recreation.(5) This water management program will also provide protection of sources of water supply.

An analysis of observed water quality in the waters receiving a municipality's discharges can indicate which parameters are in violation of specified water quality objectives. From this, a municipality can derive a target for the control of its pollution sources within its boundaries. When a municipality has multiple pollution sources, the problem becomes increasingly complicated with respect to which source(s) should be controlled and to what degree.

A "Pollution Control Strategy" (PCS) process has been developed to assist municipalities to systematically analyze the control options of multiple pollution sources in order to arrive at the most cost-effective solution in meeting the specified water quality objectives. For example, a municipality, situated on a sensitive receiver, has multiple beneficial water uses as shown in Figure 7. Water quality problems identified are algae growth, periodic fish kills in dry weather, and closing of beaches after rain. Pollution sources are multiple and include agricultural runoff, industrial and urban discharges consisting of those from sewage works, combined sewer overflows and stormwater (Figure 7). Further analysis shows that these pollution sources contribute to algae growth by nutrient enrichment of water, to fish kills during dry weather by rendering low dissolved oxygen level in stream, and to beach closings during wet weather via bacterial contamination (Figure 8). Obviously, these sources needed to be control to protect beneficial water uses. The question is which sources to be controlled and to what degree; and this can be answered via the PCS process. By constructing pie-charts such as those shown in Figure 9, for various pollutant parameters, the relative contributions from each source can be determined (e.g. significant BOD loadings come from industrial discharges; bacteria or phosphorus loadings largely come from stormwater or combined sewer overflows. So far, toxic pollutants have not been investigated in this example; however, similar procedure can be applied for toxics as well, if necessary). Various control options, such as those shown in Figure 10, can now be assessed with respect to their effectiveness in pollutant load reduction and the corresponding water quality improvement. Other factors related to economic, environmental and social constraints must be taken into account during the assessment. Technical guidelines on the assessment process have been prepared. In this example, five preliminary options are produced as shown in Figure 11. After further assessments, the final choice is No. 2 option (i.e. to construct combined sewer overflow detention basin and upgrade industrial treatment), because it satisfies all the water quality objectives for both dry and wet weather conditions. By comparison, the traditional approach of upgrading the sewage works will also provide a solution to water quality problems but at a much higher cost with lower public acceptance. On the other hand, street sweeping and stormwater retention option may have lower cost, but does not really solve the problem.

The PCS process will get progressively complicated with control of multiple sources under both present and future conditions to meet multiple water quality objectives. The process will be even more complicated if adjacent municipalities have competing water uses of the receiver or if the loadings from pollutant sources are intermittent and variable in nature. Nevertheless, this is considered to be the best method to arrive at cost-effective solutions and to deterime if a municipality needs to treat its urban runoff (as compared to treating other sources instead) for quality control purposes in order to meet identified local water quality contraints. If quality control of urban drainage is required, then the requirements can be considered at both the Master Drainage Plan and Stormwater Management Plan stages to allow possible integration with quantity control measures to maximize benefits.

3.4. Additional Benefits for PCS Process

It is anticipated that future capital pollution control undertakings by municipalities will fall under the requirements of the Environmental Assessment Act. While both the PCS and the Class Environmental Assessment documents stipulate the "evaluation of alternatives", the practical guidelines and techniques for assessment and systematic trade-off of alternatives are contained mainly in the PCS document. Thus the PCS should provide the technical approach and details needed to fulfill most, if not all of the EA requirements. Municipalities requiring more than a small undertaking to resolve water quality problems can particularly benefit from PCS preparation because it provides a perspective and an overall rationale for all the undertakings prescribed.

3.5 Technical Guidelines

To facilitate policy implementation, the following technical guideline documents have been prepared as part of the Implementation Package:

- Urban Drainage Design Guidelines using the Major/Minor System Concept.
- Erosion and Sediment Control Guidelines for Urban Construction Sites.
- Pollution Control Strategy Formulation.

In addition, methods of streamlining and clarifying the existing application-review-approval process of drainage works are provided in the Implementation Package.

4. PRESENT STATUS ON THE POLICY DEVELOPMENT

The proposed Policy Implementation Strategy has been completed by the Committee and reviewed by selected technical organizations, the Federal Government as well as by the agencies participating in the Strategy development. Comments from the review have been received and will be incorporated into the revised document.

All the technical guidelines supporting policy implementation have now been drafted and these documents will go through a similar review process shortly.

It is expected that the entire Policy Implementation Package will be finalized by the inter-agency Committee before the end of this year. The Package will then be submitted to the Ontario Government for approval.

5. FUTURE TREND IN URBAN DRAINAGE MANAGEMENT

As a result of our substantial efforts devoted to the Urban Drainage Management Program, particularly the policy development activities, considerable progress has been made. Municipal and development industry's attitudes towards modern drainage planning and practices have become positive. It is anticipated that the following will be adopted and phased in:

- Urban Drainage Planning Process (i.e. MDP, SWMP, etc.) will be incorporated into the normal Land Development Process to maximize benefits of urban drainage control.

  More importantly, at the urban drainage planning stage, opportunity exists to integrate both quantity and quality control where necessary. Drainage planning approaches as well as drainage design and practice will be made consistent province-wide. Modern concepts, such as major-minor drainage system will be used to optimize servicing capacity and property protection at least cost. Erosion and sediment control will be practised during construction as an effective means to reduce sediment pollution and conserve top soil. Multi-agencies co-operation will be emphasized. Municipalities, in particular, will get more involved, and they will be the prime mover of the program. In fact, a number of municipalities are already using, to a varying degree, these modern planning and design practices.

- Pollution Control Strategy will be used to integrate multiple point and non-point sources control measures in order to arrive at a cost-effective solution to meet identified local water quality problems (this includes the use of PCS process to decide if treatment of urban drainage is warranted on site-specific basis). In fact, several basin-wide and municipality-wide PCS type projects have been completed and several more are on-going in Ontario to test out and demonstrate the practicability of this approach to solve site-specific problems. Notable examples are the Grand River Basin Water Management Study, the Rideau River Stormwater Management Project, the Stratford-Avon Environmental Management Project, the Toronto Area Watershed Management Strategy Study and the City of Cornwall Pollution Control Strategy Formulation. The end results of these projects would be the formulation and implementation of optimal pollution control plans for the respective watersheds or municipalities taking into account both point and non-point sources.

- Hazardous contaminants in urban drainage will receive more attention, and their control will be considered as a component of the comprehensive hazardous contaminant management program limiting the discharge from all sources to the environment.

  At the present time, research efforts in this area have been directed mainly towards problem characterization. Federal and provincial studies are on-going to identify and quantity hazardous substances from stormwater runoff and combined sewer overflows. Seven study areas have been investigated in four cities (Burlington, Cornwall, Hamilton and Sarnia). Monitoring and assessments are being conducted in Toronto as part of the Toronto Area Watershed Management Study, and in Fort Erie, Niagara Falls and Welland as part of the Canada-U.S. Niagara River Study.

  Although a large number of hazardous contaminants have been found in urban drainage, they are generally present in very low concentrations. Based on preliminary data, some of the hazardous contaminants identified in stormwater in concentration levels of some concern include metals (such as lead, zinc, copper), organics (such as PCB's) and pesticides (such as DDT, chlordane and BHC's). Data from our combined sewer overflow studies are not yet available.

6. THE U.S. NATIONWIDE URBAN RUNOFF PROGRAM (NURP)

Urban runoff quality problems in the U.S. are being addressed at the federal level by NURP. This Program excludes the area of combined sewer overflows, and was funded as a special research/demonstration effort concentrated on the refinement of problem definitions and quality control technologies evaluation. Twenty eight projects were funded involving state, area-wide and municipal governments working jointly with US EPA. Preliminary report of this Program has been published,(6) and the final report of these projects is scheduled for the end of 1983.

Highlight of the NURP findings can be summarized in the following:

- Analysis of a data base (in excess of 1,000 separate monitored storm events) has shown that the event mean concentrations (EMC's) of pollutants in stormwater are quite variable, essentially uncorrelated with storm volume, and can be quite adequately described by log normal probability distributions. This permits a convenient and concise description of the highly variable pollutant levels in stormwater and provides perspective on the occasional very high or low concentrations observed in studies. Concentrations of conventional pollutants and selected metals of interest in stormwater have been measured and they are comparable to Ontario data. In addition, information on fecal coliform concentrations and priority pollutants have also been gathered.

- Probabilistic planning level models have been developed, and are being tested. One of these addresses receiving water impacts which result from intermittent, variable storm runoff pollutant loads, as well as the water quality improvements from proposed control measures. The other model estimates long term average performance of recharge or sedimentation type detention basins which receive stormwater runoff.

- Three types of stormwater quality control measures have been evaluated with their results summarized herein.

  Detailed and extensive studies of street sweeping, as a pollutant load reduction measure for urban areas, were conducted by 5 cities under the NURP program. Results to date have yet to demonstrate any significant level of universal reduction in total pollutant loads from the overall urban catchments which were monitored. Consequently, street cleaning is suggested to have potential pollutant load reduction capabilities only for quite specific situations rather than as a broad scale measure of general effectiveness. When carried out under normal manner and frequency, such practice may not be effective for municipalities in the Great Lakes area.

Detention devices which operate either by recharge or by sedimentation have proven to be capable of significantly reducing pollutant loads from stormwater. NURP data indicate that recharge basins are quite effective in reducing particulates, coliform bacteria and heavy metals. Observed performance results from some of the NURP retention basins are listed in Figure 12. Performance levels cover a wide range for individual storms processed by a particular basin. Overall average performance also differs substantially for different basins depending on factors such as the overflow rates, residence time and basin configuration. All these results point to the fact that detention devices can provide both quantity and quality controls, but only if they are designed properly for both purposes.

It is interesting to note that these NURP performance data on control measures are comparable to those obtained from several similar Canadian studies. Results of studies in Ottawa, Ontario, however have shown that street cleaning may have potential benefits for the control of pollutant loads from frequent storm events, if the cleaning is scheduled at appropriate intervals to suit the purpose.

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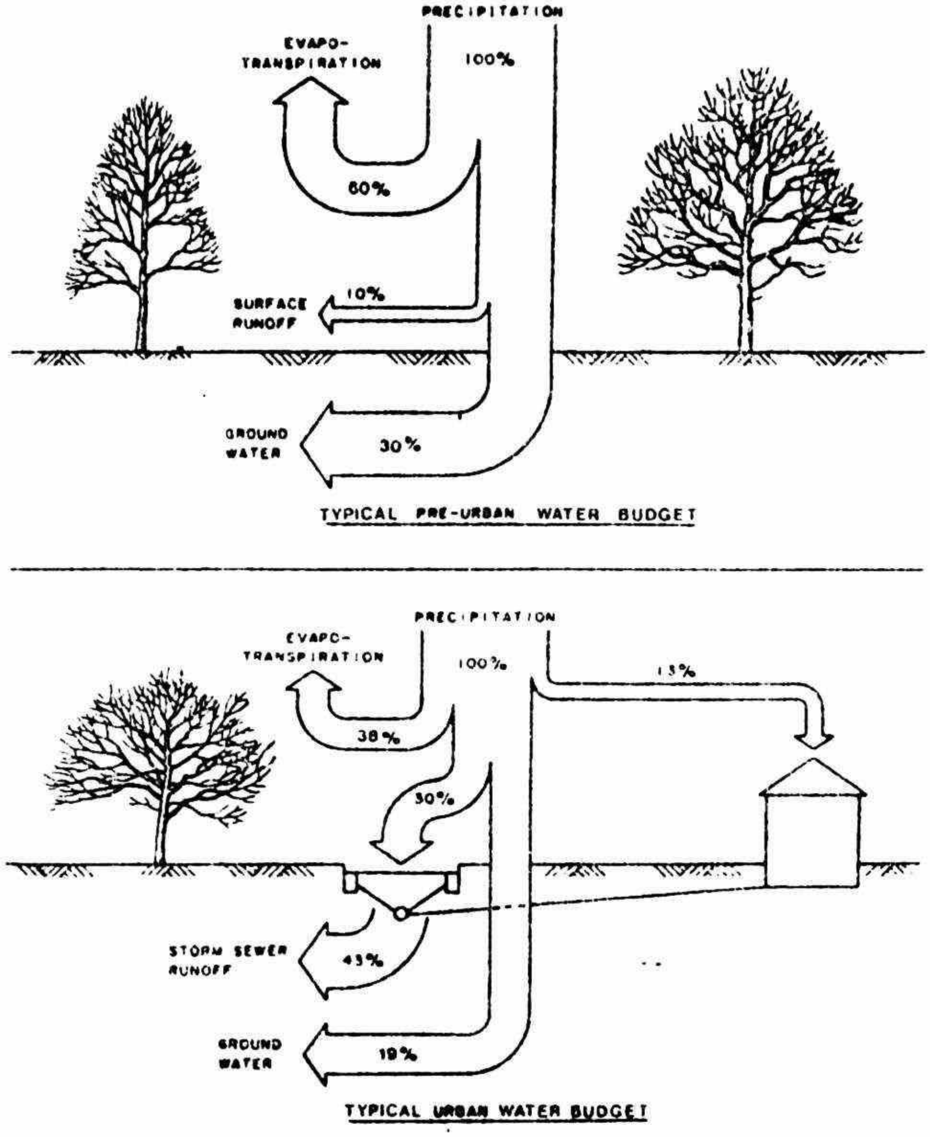


TYPICAL PRE-URBAN WATER BUDGET

TYPICAL URBAN WATER BUDGET

FIGURE 1 HYDROLOGIC CHANGES RESULTING FROM URBANIZATION

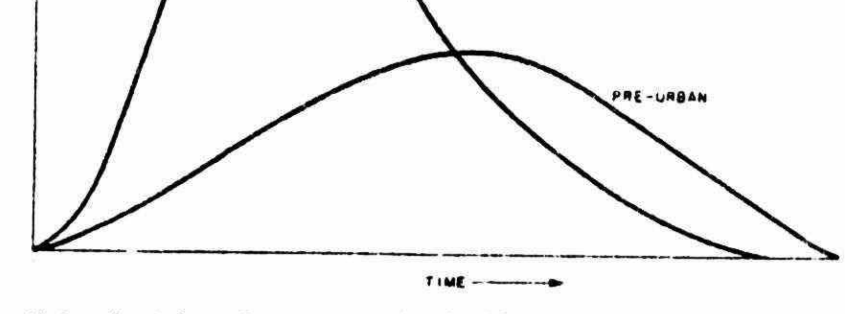


Figure 2

Urbanization Increases Peak Flows and Runoff Volumes
(the area under the curves)

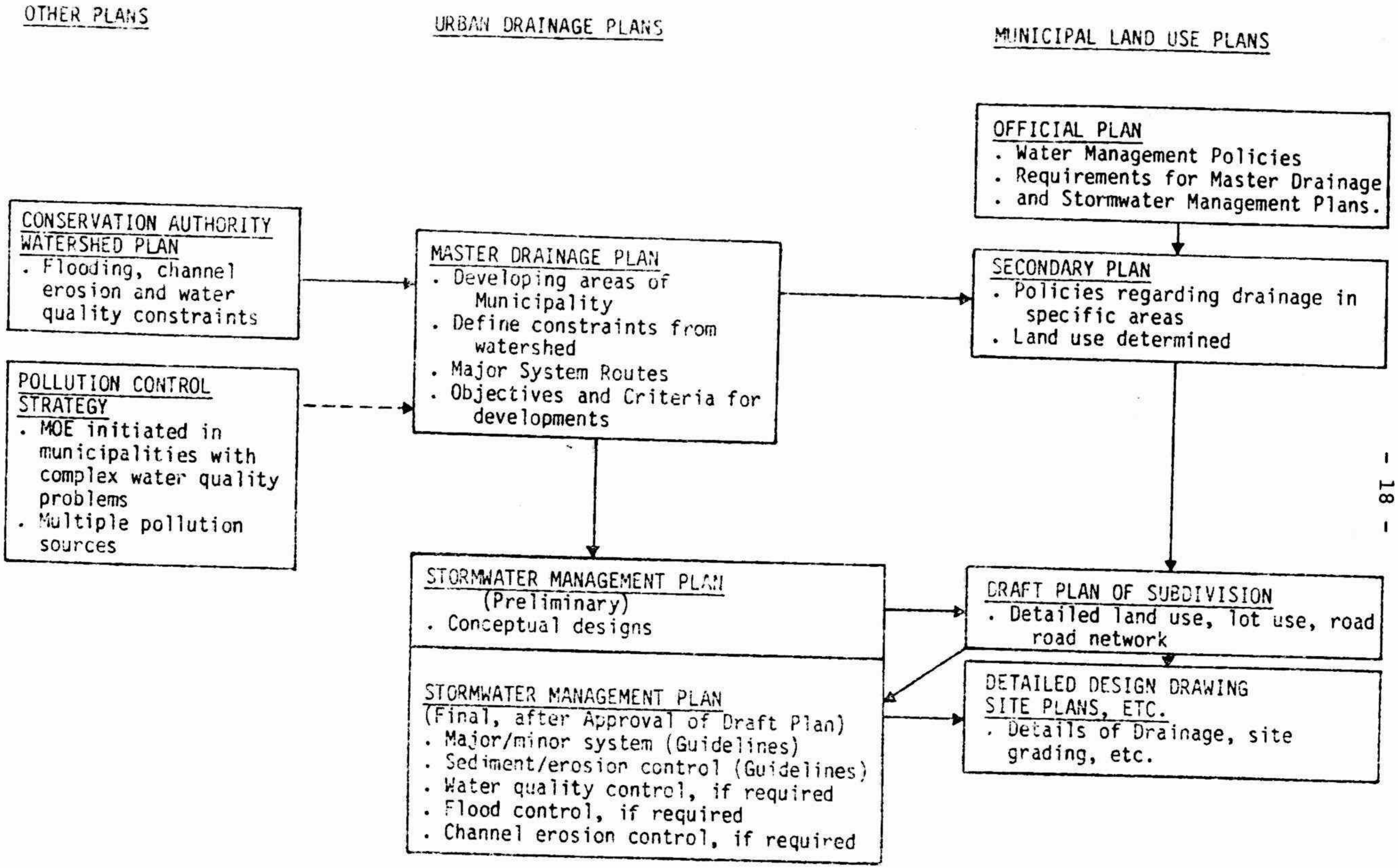

OTHER PLANS
URBAN DRAINAGE PLANS
MUNICIPAL LAND USE PLANS
OFFICIAL PLAN
. Water Management Policies
. Requirements for Master Drainage
. and Stormwater Management Plans.
CONSERVATION AUTHORITY WATERSHED PLAN
. Flooding, channel erosion and water quality constraints
MASTER DRAINAGE PLAN
. Developing areas of Municipality
. Define constraints from watershed
. Major System Routes
. Objectives and Criteria for developments
SECONDARY PLAN
. Policies regarding drainage in specific areas
. Land use determined
POLLUTION CONTROL STRATEGY
. MOE initiated in municipalities with complex water quality problems
. Multiple pollution sources
STORMWATER MANAGEMENT PLAN (Preliminary)
. Conceptual designs
DRAFT PLAN OF SUBDIVISION
. Detailed land use, lot use, road road network
STORMWATER MANAGEMENT PLAN (Final, after Approval of Draft Plan)
. Major/minor system (Guidelines)
. Sediment/erosion control (Guidelines)
. Water quality control, if required
. Flood control, if required
. Channel erosion control, if required
DETAILED DESIGN DRAWING SITE PLANS, ETC.
. Details of Drainage, site grading, etc.

FIGURE 3 INTERRELATIONSHIP BETWEEN URBAN DRAINAGE PLANNING AND LAND USE PLANNING

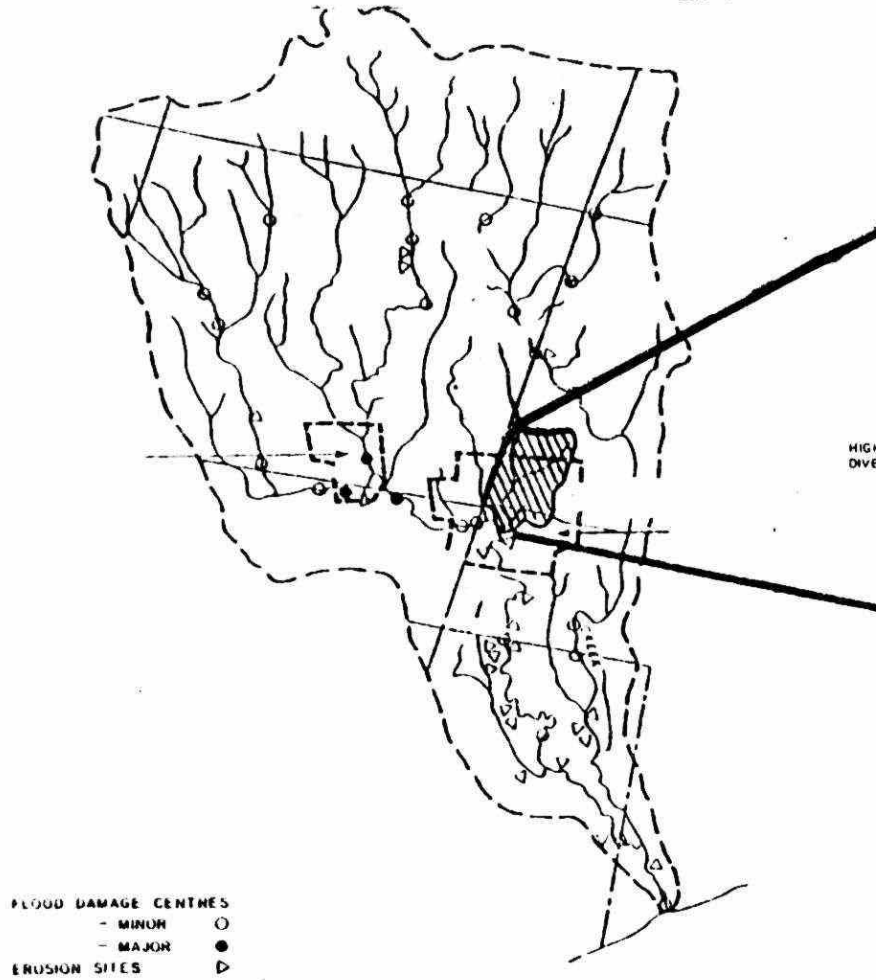
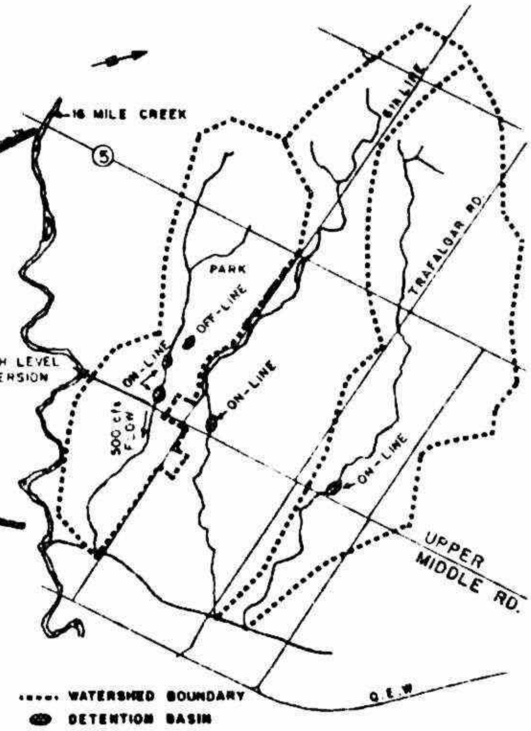


FIGURE 4(a)



MASTER DRAINAGE PLAN

FIGURE 4(b)

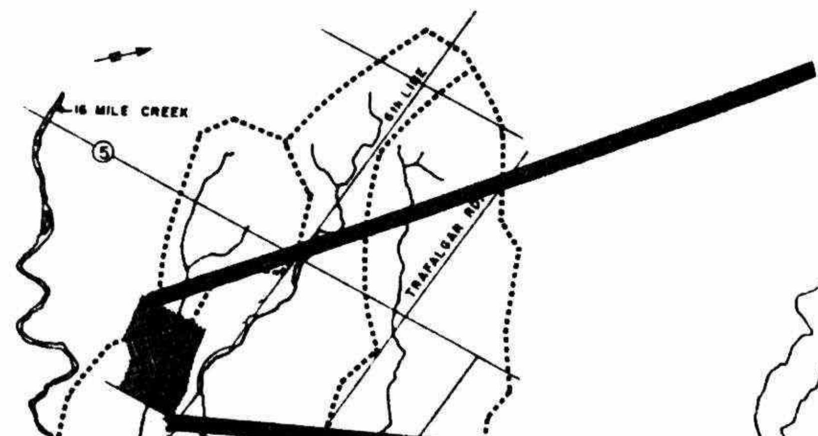
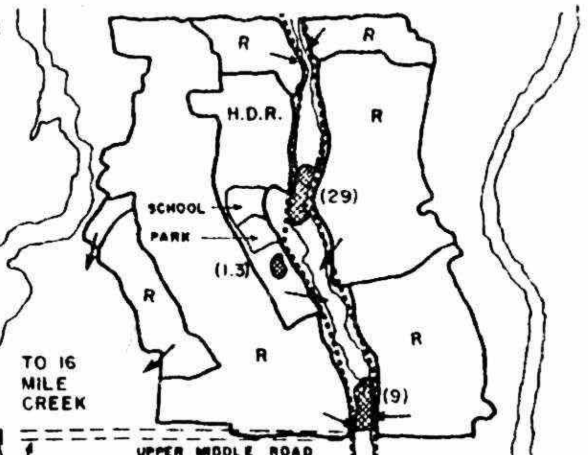


FIGURE 5 (a)



STORMWATER MANAGEMENT PLAN

FIGURE 5 (b)

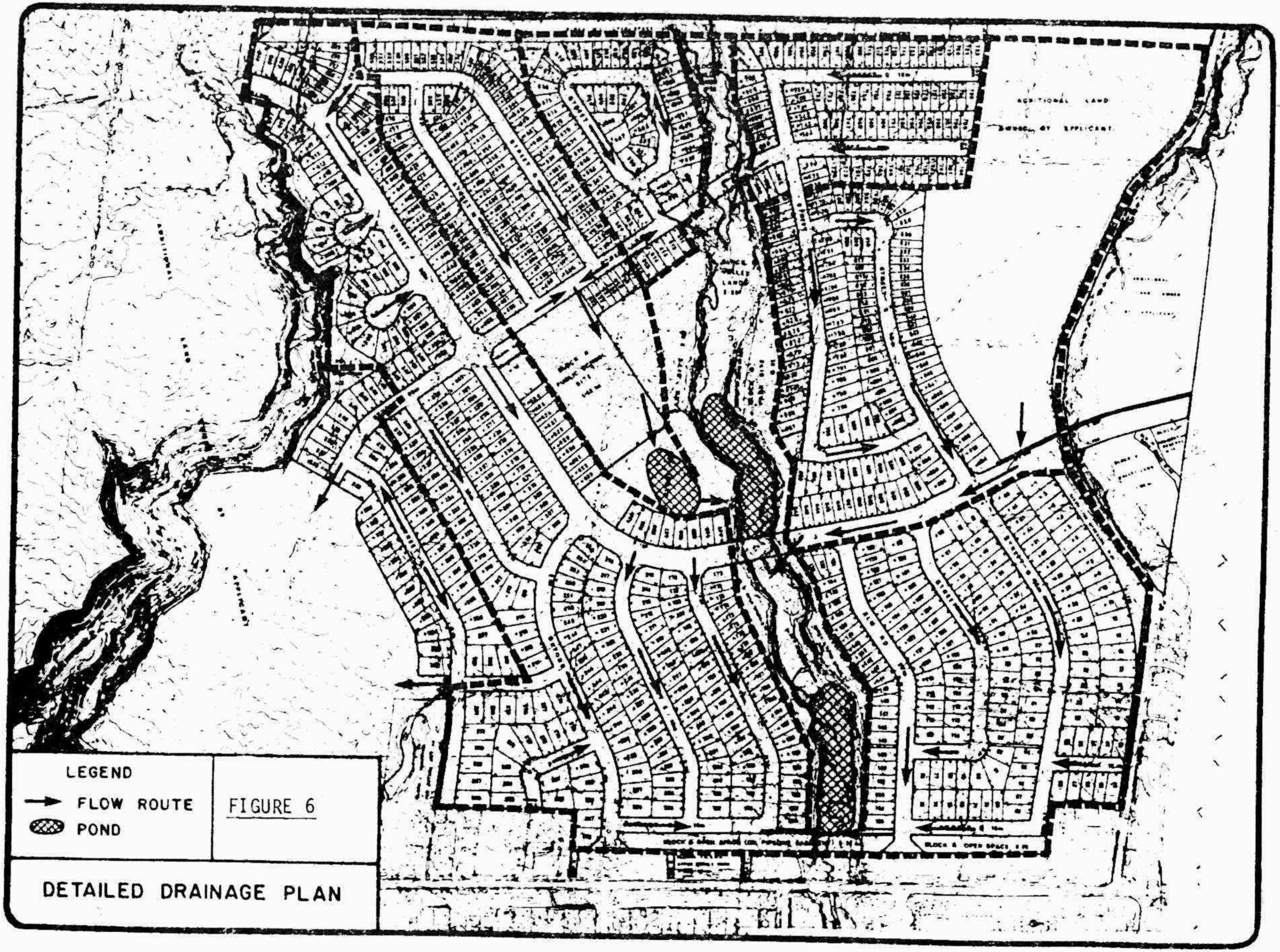


FIGURE 6

DETAILED DRAINAGE PLAN

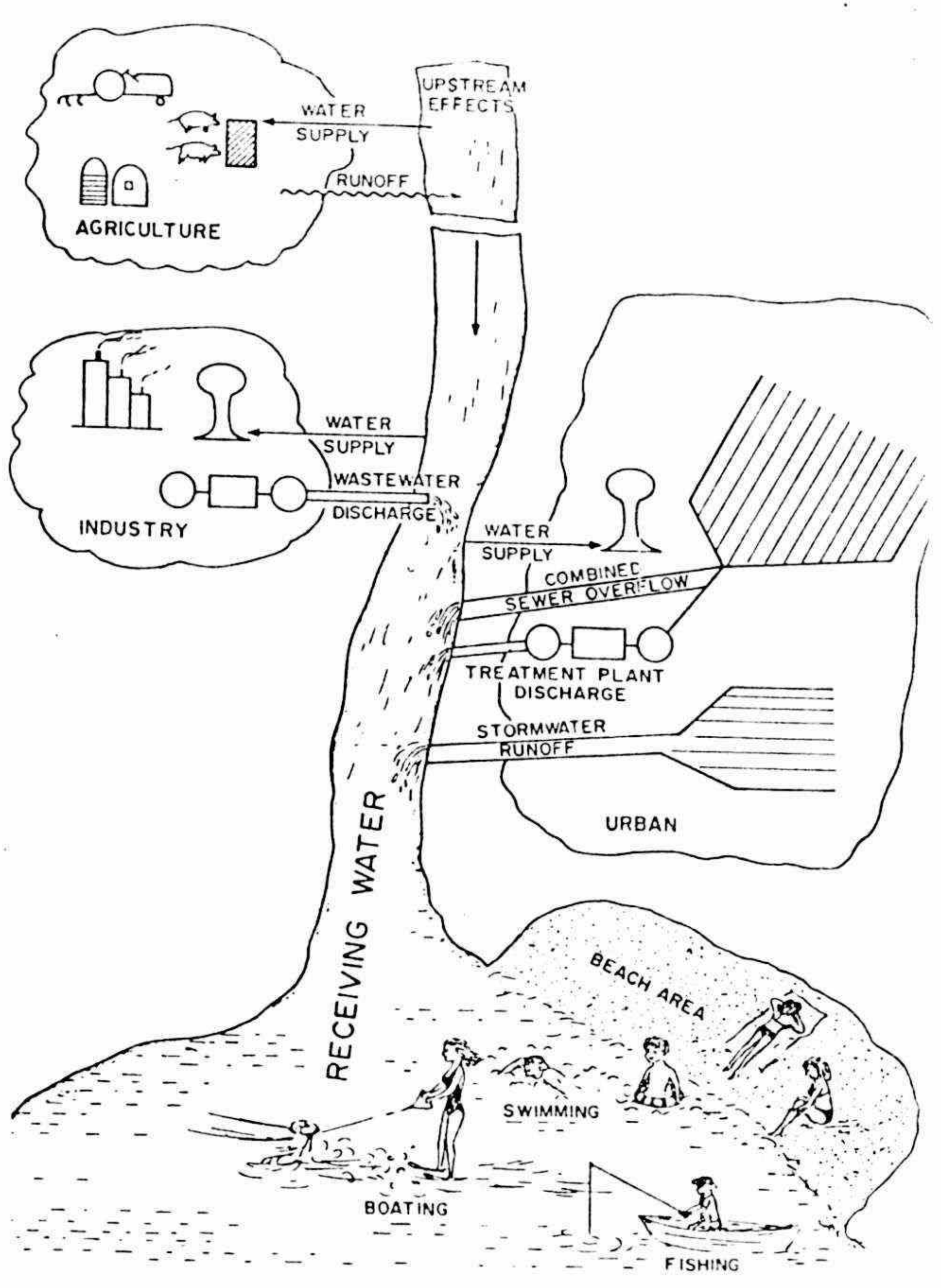


FIGURE 7 - POLLUTANT SOURCES AND WATER USES

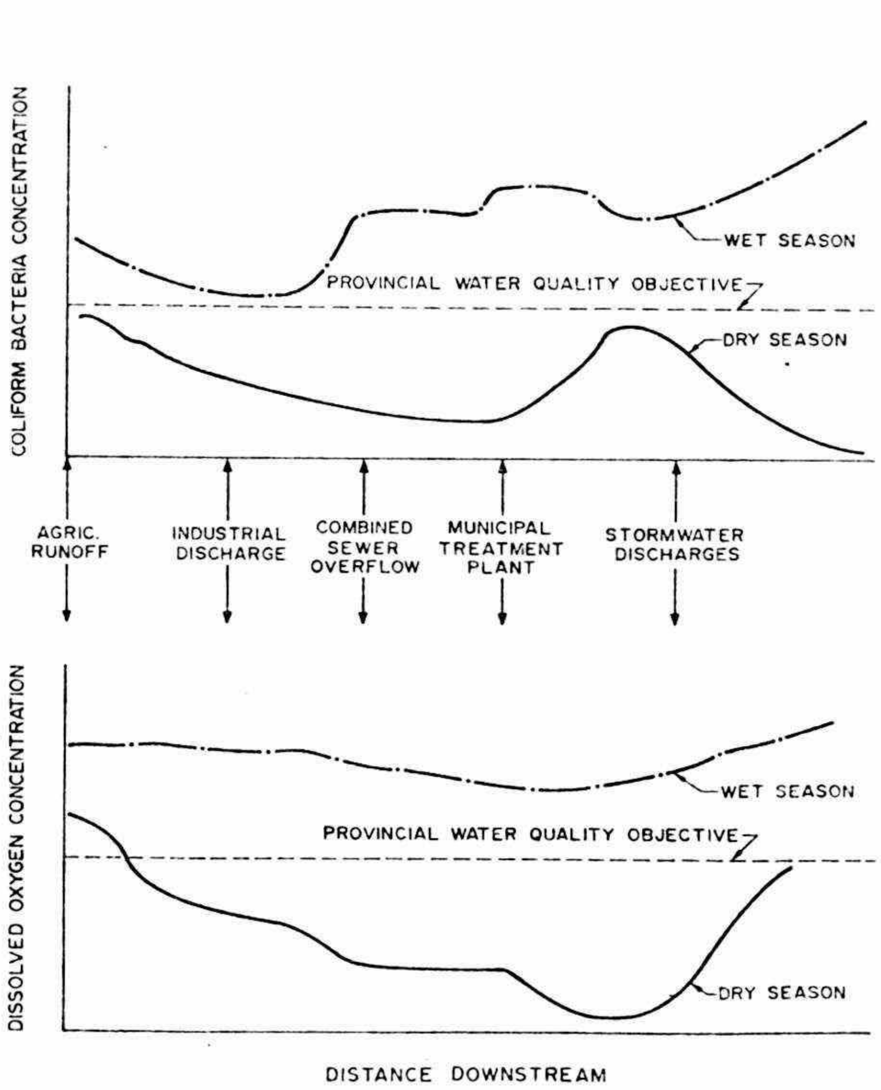
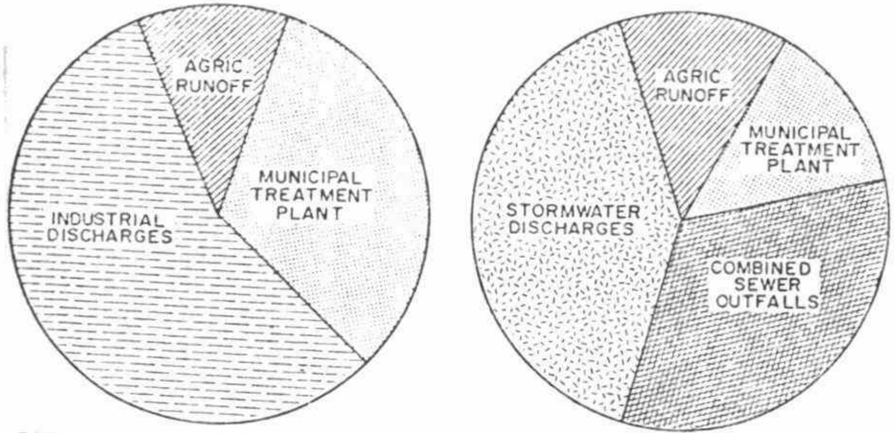
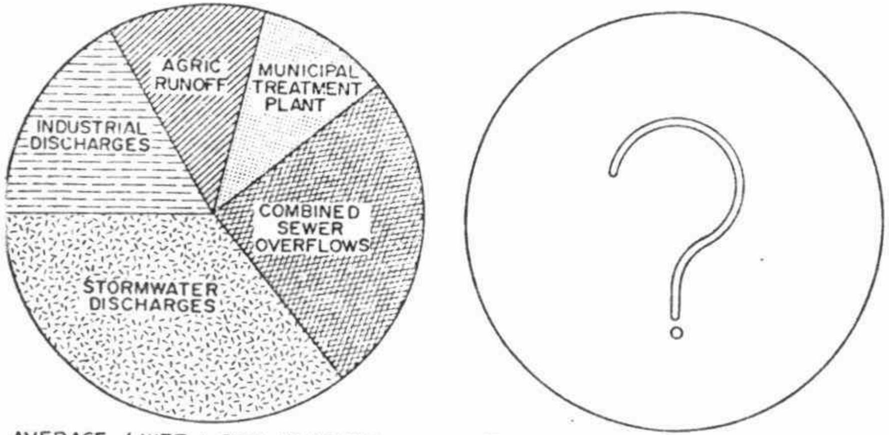


FIGURE 8 — WET AND DRY SEASON COLIFORM AND DISSOLVED OXYGEN DATA FOR HYPOTHETICAL PCS AREA



TOTAL BOD_5 LOADING DURING DRY SEASON (kg/day)

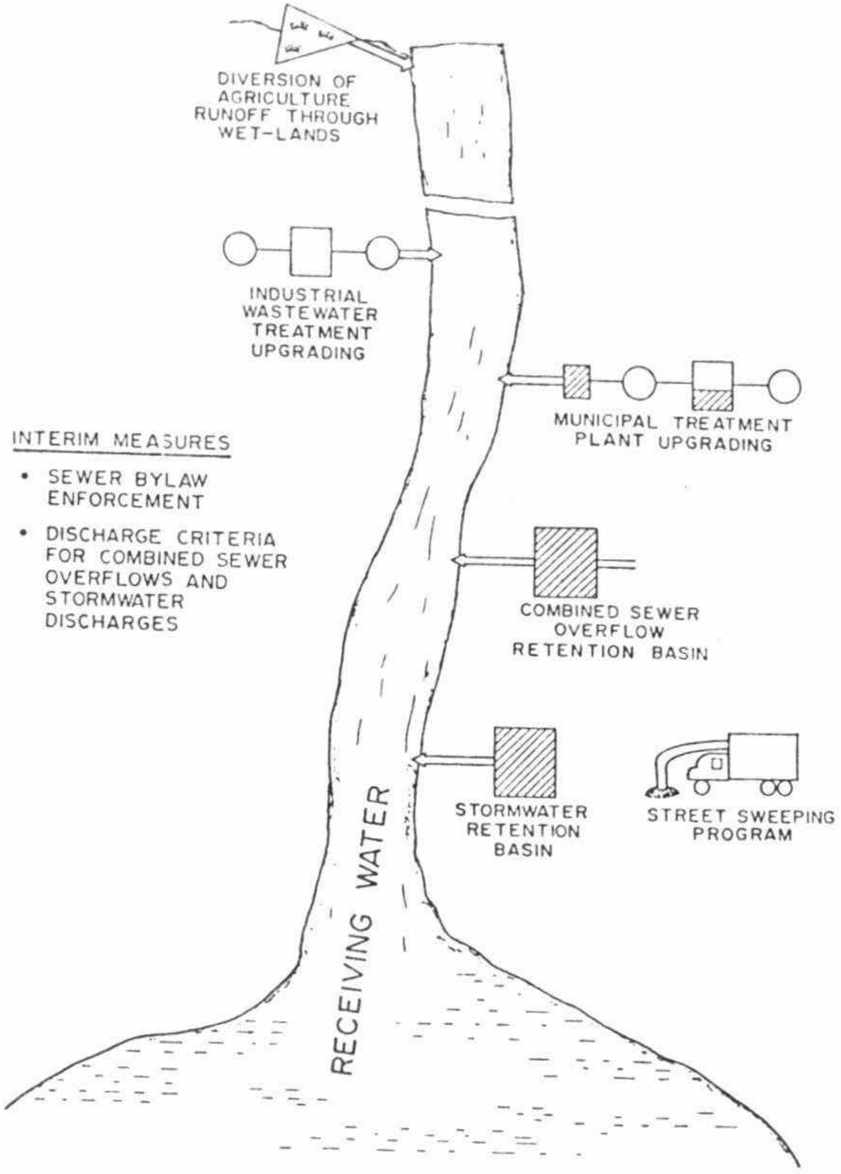
TOTAL COLIFORM INPUT DURING WET SEASON (#/day)



AVERAGE (WET + DRY SEASON) PHOSPHORUS LOADING (kg/day)

TOXIC MATERIALS LOADING (kg/day)

FIGURE 9 - MAGNITUDE OF POLLUTANT LOADINGS FOR HYPOTHETICAL PCS AREA


DIVERSION OF AGRICULTURE RUNOFF THROUGH WET-LANDS
INDUSTRIAL WASTEWATER TREATMENT UPGRADING
MUNICIPAL TREATMENT PLANT UPGRADING
COMBINED SEWER OVERFLOW RETENTION BASIN
STORMWATER RETENTION BASIN
STREET SWEEPING PROGRAM
RECEIVING WATER

INTERIM MEASURES

- SEWER BYLAW ENFORCEMENT
- DISCHARGE CRITERIA FOR COMBINED SEWER OVERFLOWS AND STORMWATER DISCHARGES

FIGURE 10 — ABATEMENT ALTERNATIVES FOR HYPOTHETICAL PCS AREA

FIGURE 11. DETAILED ASSESSMENT MATRIX FOR HYPOTHETICAL PCS AREA

ALTERNATIVE OR COMBINATION OF ALTERNATIVES	COST ($ x 10^6)	PROTECTION OF BENEFICIAL USES		EQUITY DISTRIBUTION	RELIABILITY	PUBLIC ACCEPTANCE
		DRY SEASON	WET SEASON			
(1) Street sweeping and combined sewer separation	2.5	Periodic fish kills possible	All water quality objectives met	Fair	Some Un-Certainty	Intermediate
(2) Combined sewer overflow basin and upgrade industrial treatment	3.0	All water quality objectives met	All water quality objectives met	Good	High	High
(3) Municipal treatment plant upgrading	7.5	All water quality objectives met	All water quality objectives met	Poor	High	Intermediate
(4) Stormwater Retention Basin and Agricultural Runoff Diversion	2.0	Periodic fish kills possible	All water quality objectives met	Good	Moderate	Intermediate
(5) Street sweeping and Stormwater Retention Basin	1.5	Periodic fish kill possible	All water quality objectives met	Fair	Moderate	Low

Figure 12

OBSERVED PERFORMANCE OF RETENTION BASINS (NURP)

Project and Site	No. of Storms	Size Ratios *		Average Mass Removals - All Storms (Percent)									
		QR/A	VB/VR	TSS	BOD	COD	TP	Sol P	TKN	NO_3	T.Cu	T.Pb	T.Zn
Lansing Grace St. North	18	8.75	0.05	(-)	14	(-)	(-)	(-)	(-)	(-)	(-)	9	(-)
Lansing Grace St. South	18	2.37	0.17	32	3	(-)	12	23	7	1	(-)	26	(-)
Ann Arbor Pitt-AA	6	1.85	0.52	32	21	23	18	(-)	14	7	.	62	13
Ann Arbor Swift Run	5	1.92	1.10	85	4	2	3	29	19	80	.	82	(-)
Ann Arbor Traver Cr.	5	0.31	0.53	5	(-)	15	34	56	20	27	.	.	5
Long Island Unqua	11	0.10	1.74	.	.	.	.	.	.	.	.	77	.
Lansing Waverly Hills	29	0.09	7.57	91'	69	69	79	70	60	66	57	95	71
NIPC Lake Ellyn	23	0.10	10.70	84	.	.	34	.	.	.	71	78	71

*

QR/A = The overflow rate for the mean storm -- cubic feet per hour runoff rate and square feet of basin surface area (= ft/hr). The lower this rate, the better will be expected performance under dynamic conditions.

VB/VR = The volume of the basin relative to the mean storm runoff volume. The larger this ratio, the smaller the volume displaced by the storm and the longer the residence time for quiescent settling. Larger values of this ratio imply greater removals.

URBAN DRAINAGE POLICIES

A MUNICIPAL ENGINEER'S VIEWPOINT

by: W.J. Warwick,
Borough of Scarborough

URBAN DRAINAGE POLICIES

A MUNICIPAL ENGINEER'S VIEWPOINT

I am pleased to be here this morning to participate in this seminar on Urban Drainage Management. What I wish to talk about is the implementation of urban drainage policies in Ontario from a Municipal Engineer's viewpoint. I don't believe anyone can really give you an overall consensus of opinion of the way the Municipal Engineers view these urban drainage policies. I do hope however, that the viewpoint of my colleagues in Municipal Engineering would not differ considerably from what I am going to say.

These policies and their implementation are of direct concern to all Municipal Engineers across Ontario. I look forward to seeing the changes in the fabric of storm sewer systems, that these policies will create. Proper and careful use of these policies must be and I believe will be in the public's interest. It is my feeling that these policies are long overdue, and changes in our outlook on urban drainage are needed. That statement of mine may be strange to some of you in the audience, and later on I will expand on what I have just said.

At this time, I do not want to dwell on the history related to this topic, but I do want on behalf of the Municipal Engineers Association to compliment the Committee for the time and effort they have put into formulating the policies, and the implementation package that goes with them. This was not an easy task to undertake and we can now say that the end is in sight or perhaps I should say they have reached the end of the beginning. Now comes implementation, at last.

Municipal Engineers want to help those involved to implement this phase. This will require extensive education and communication. The audience is large, it includes Municipal Engineers, Consultants and Provincial staff. It should also include Developers, Planners and the public who are interested.

I would like to pose to you this question. How are Municipal Engineers involved in urban drainage policies? The answer to me is obvious and it should be obvious to you.

Well, the Municipal Engineer is the one who implements these policies in his municipality and operates the system after construction. He wants the best system at least cost, and this must include ease and economics of maintenance. He is the one who is responsible to his Council for these policies that he recommends for implementation in his community. He is a key element if we are serious about a new Urban Drainage Policy in

Ontario, and of course I must not forget the review process by the Municipal Engineer of development proposals. Some of my colleagues in the Municipal Engineering field are not ready to accept this new technology partly because they see no reason to change and partly because they do not know enough about it to be comfortable (they need to be educated and informed).

If we ignore the importance of education and communication, the implementation of these policies will not succeed. will not succeed. This education process must be carried out on a continuous basis and not on a one shot effort. I would like to see the education training program organized as stated in Recommendation No. 10. Up to now many people and groups have been involved in trying to get a new stormwater technology across to those interested in this subject. For example, Paul Wisner with his seminars he has held in Ottawa, and one that I was involved in, which was a separate two day seminar, attended by over 200, on the Practical Implementation of Storm Water Management Techniques held in the fall of 1980. All of these have been good for us but what Municipal Engineers want is a continuing education program. To this end, I will commit M.E.A., possibly through the Curriculum Development Advisory Committee, which is chaired by John Warren of St. Catharines, to assist in the development of a proposed training program.

While on this aspect of a Municipal Engineer's involvement in Urban Drainage Policies, I should advise you of another positive approach taken. For the past twelve years, I have organized a course in Sewer Design which has been co-sponsored by M.E.A. and M.O.E. It is four days in length and is intended to broaden the understanding and knowledge of staff who are engaged in the design of storm and sanitary sewers. The thirteenth course will be held this October at the Nottawasaga Inn. For the past four years the following topics have been included.

-- What is Storm Water Management?
-- Hydrograph Techniques
-- Major/Minor Concepts and Design
-- Detention Storage Design

I see the need for follow-up of the Urban Drainage Policy Implementation Committee by either the same committee or another committee with new members. Their task might be the following:

(1) Refine the policies as experience dictates
(2) Re-evaluate the policies on a cost benefit basis
(3) Review public acceptance of these policies
(4) Ascertain the effectiveness of the education and communication program

I personally have been fortunate in following the activities of the Implementation Committee over the past few years. I have seen the Executive Summary, Minutes of their Meetings, and have studied their recommendations. I would like to highlight just three of them.

RECOMMENDATION NO. 3 states that municipalities should incorporate policy statements in their official plan stipulating requirements for master drainage plans. These policies should be implemented in co-operation with conservation authorities and provincial ministries. To me there is a cost factor in the implementation of this recommendation to municipalities and to their Municipal Engineers. This may be the biggest stumbling block of all to the successful implementation, but I am confident that with time, all Municipal Engineers will endorse these recommendations on an individual municipal basis.

RECOMMENDATION NO. 8 states that municipalities should adopt drainage design standards consistent with the Urban Drainage Design Guidelines for Major and Minor Drainage Systems and Erosion and Sediment Control Guidelines provided by the Ontario Government.

I want to move very careful on this recommendation which states that municipalities should adopt standards and that municipalities should provide inspection to construction sites to monitor and enforce erosion and sediment control requirements.

Many Municipal Engineers will willingly adopt design criteria, ones in which they can believe in, but will hesitate to adopt design standards imposed upon them by the Province. With regard to the inspection requirements, Municipal Engineers will wonder about who is going to pay the cost of such inspection. We all know who, it will be the municipality.

RECOMMENDATION NO. 9 states that the Ontario Government should provide expertise centres on erosion and sediment control and on drainage design, and they should continue their research programs. From my point of view, I would like more information on these expertise centres and will they be regional in concept. i.e. how will a Municipal Engineer gain access to them and make use of them? Will Municipal Engineers be involved in the Research Programs?

However, all of the recommendations can be accepted by Municipal Engineers without significant amendment.

I would like to take advantage of this opportunity and bring to your attention a related topic that is of great importance to Municipal Engineers.

To me any backup in basements from surcharged storm sewers during heavy rainstorms is unacceptable. When this occurs the municipality should take positive steps to examine the cause of the backup. I suppose theoretically we could design and build deeper and larger storm sewers or implement some other scheme in an attempt to protect the property owner from this eventuality. But no system can guarantee 100% protection from a sewer back-up. Do you know of any? Bigger and deeper sewers are expensive and probably not worth the extra expense even if the municipality could afford it.

When back-ups do occur I wonder why there are houses in an area that get it while others in the same area do not. This is something that I feel has never been satisfactorily answered. At least not to me. This is a study that I would like to see carried out by the right group with the right objectives.

Are these back-ups caused by an undersize house connection, or by the house connection laid at a flat grade or by the house being built too low in relation to the storm sewer? All of which provides the house with a low tolerance to basement flooding. Then there is the question of the hydraulic capacity of eavestroughes and down pipes discharging to the storm sewer.

Is the answer to prevent flooded basements simply the third pipe concept or the connection of weeping tile to the sanitary sewer? This is a question that always has and will create much debate among sewer designers and operators. And it is one that I do not wish to discuss to-day.

One benefit to back-up in basements is that this shows up weaknesses in the existing sewer system. It is a benefit if you are not the one or ones with the back-up. This then indicates where improvements are required if back-ups in basements in the municipality are to be reduced.

I would like to go back to this matter of public acceptance of the new policies and the sewer system that will be constructed as a result. To my knowledge, the public have not really seen the effect of what these policies might do. They have not seen the ponding of water that is designed to occur on the street system nor to any extent the temporary detention of water in ponds.

Will it be necessary to sign specific roads in a municipality to inform users that the road is subject to surface flooding during heavy rainstorms, or it is an overland flow route?

If they see this as a deterrent to their community, they will complain to the Municipal Engineer or to their member of Council. If and when this happens, it will be up to the Municipal Engineer to convince them that this is in their interest and that they should be in favour of it. This will require the Municipal Engineer to sell to his taxpayers the benefits of these policies, and any material to be used as selling tools should be endorsed. by the Province.

Another matter I have referred to earlier is the cost aspect. We in the Borough of Scarborough were reluctant to change to any new system of storm sewer design. This reluctance emanated for the following reasons:

Probably the most important was we were not convinced that the new technology was tried and true, and was here to stay. We were concerned that it might be just a fad in somebody's mind that could easily be amended or radically changed in the future. Remember the obvious. What is built is built, and it is built to last a long time.

Secondly, it was not promoted or advanced in a way that we were confident of its benefits and

Thirdly, we recognized that any change would likely be more expensive and we wanted to be sure that that was what we wanted in Scarborough. Since that time, we are now utilizing storm water management practices to the best of our ability and of course as many of you know, we do not like that expression of storm water management, but we prefer the expression "new techniques in storm water management". It is our belief that we always had management of our storm sewer system, although it did not match the acceptance of some designers.

To summarize what I have said this morning, I believe that Municipal Engineers have been waiting for the publishing of these policies and want to implement them. To do so will require an extensive and intensive training program. Although I did not refer to this earlier, if legislation is required to be changed or amended in order to implement any or all of the policies then let it be done in order to provide a better system of storm drainage in Ontario without delay.

NONPOINT POLLUTION MANAGEMENT IN THE OCCOQUAN RIVER BASIN OF NORTHERN VIRGINIA

By: John P. Hartigan,
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ABSTRACT

Regional nonpoint pollution management program for 1,502 km^2 river basin with 37.1×10^6 m^3 water supply reservoir located at its mouth was described. Four counties, three cities, and a regional water authority participated in the program which was administered by a regional planning agency.

Management program began in 1979 following water quality monitoring and modelling studies indicating that, despite an advanced wastewater treatment (AWT) plant constructed upstream of the reservoir, future urban development would accelerate reservoir eutrophication unless control measures were implemented.

Local nonpoint pollution management programs applied to urban areas included land use controls, stormwater management controls (e.g. wet ponds), and vacuum street sweeping (in one small city). Fairfax County's recent downzoning of approximately 11,000 ha to residential zones requiring a minimum 2-ha lot size has resulted in almost 30 lawsuits by private developers seeking to overturn this land use control.

Management programs applied to agricultural areas have focused on the use of conservation tillage practices.

Water quality monitoring and modelling studies that have documented effectiveness of alternate control measures and impacts of future land use projections were described.

PROVINCE OF ONTARIO

URBAN DRAINAGE DESIGN GUIDELINES

by: Andrew F. Brodie, P.Eng.
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Thornhill, Ontario

INTRODUCTION

Ontario's new urban drainage design guidelines were prepared by a group of sub-committees under the guidance of the Urban Drainage Implementation Committee. Each committee had representatives of the MOE, MNR, MUAH, MTC, conservation authorities and the municipal engineers association. What has emerged is a coherent set of policies which meet all of the disparate requirements of the various agencies. This could not have been achieved without excellent cooperation between all of the individuals and their agencies, a cooperation which was so capably fostered by Don Weatherbe, Peter Seto and Guirish Sardesai who acted as co-chairmen. Several consulting firms were retained to assist in preparing the guidelines and the supporting data for the Cabinet. Everyone deserves congratulations for a job well done.

But why was it necessary to prepare urban drainage guidelines? Bluntly, the answer is economics and education. In the mid 1900's, municipal engineers stressed the level of convenience on roadways. This led them to install curb and gutter (eliminating ditches), paved sidewalks, catchbasins and storm sewers. The system was very efficient at collecting and transporting the runoff from the more frequent storms. When the public complained about inconvenience, primarily during snowmelts, the answer was to install another catchbasin. Too many catchbasins then led to too much water entering the storm sewer system during both intense thunderstorms and spring snowmelt. The storm sewers then surcharged, and where foundation drains were connected to the storm sewers, sometimes the basements were flooded. Failure to provide safe overland flow paths at low points in roads often led to surface flooding of some properties.

While these on-site problems were severe, the problems downstream were usually worse. The effects of urbanization and the "efficient" storm sewer systems were to increase both the volume and peak

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INTRODUCTION cont'd

magnitude of stormwater runoff. In the major system watercourses and lakes, these effects were manifested as increased flood damage, increased erosion damage and increased pollution. To illustrate the magnitude of some of these effects, consider the following examples.

(a) In the 1950's, one municipality developed a 100 hectare parcel using the conventional drainage system. It is currently faced with having to spend $4.2 million on remedial erosion and bank stability works.

(b) In the last 25 years, Ontario has spent over $200 million on remedial works through the MNR, the conservation authorities and their member municipalities. And yet, a great deal has been left undone.

Stormwater management, or urban hydrology, is an attempt to resolve both the on-site and downstream problems by:

(a) establishing a preventive programme that will be less expensive to society than the remedial one;

(b) establishing the same level of protection against flood damage to properties caused by water below or above the ground as we have had on our watercourses for many years (Conservation Authorities' Act); and

(c) establishing control of the quality of urban runoff to the degree dictated by downstream conditions.

In doing this, it is necessary to integrate into one coherent set of policies the concerns that used to be handled separately by various agencies such as the municipality, MNR, MOE, MOH and the conservation authorities. It requires a higher level of co-operation between departments in a municipality during planning, implementation and operation and maintenance. It also requires that engineers, planners, biologists, economists and sociologists work together to produce more viable and exciting urban developments.

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INTRODUCTION cont'd

That it can be done has already been proven. That it can be done economically has also been proven in Brampton, Burlington, Guelph, Markham, Mississauga, Oakville and Ottawa-Carleton, to name only a few. The total costs comprise both on-site and off-site (external) works. Based on my experience with over 70 projects in the last five years, the average initial capital cost of on-site works has been slightly higher than those for a "conventional drainage system". In four cases, the cost was less. In ten cases, the extra cost was less than $500/ha. The highest cost was $2000/ha.

In only two cases out of fifty have there been any off-site works required downstream of developments incorporating on-site SWM measures. This is in marked contrast to the experience with conventional drainage designs where large pipes, channels and outfalls were the norm. Taking both on-site and off-site works together, the total initial capital costs of developments using stormwater management are considerably less than using the conventional approach of the 1950s and 1960s. Table 1 illustrates this with the costs of actual projects. This is not a selective list, it happens to be the total list for those jobs estimated both ways.

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TABLE 1 - COMPARATIVE COSTS OF DRAINAGE SYSTEMS EXCLUDING STORM SEWERS IN DEVELOPMENT

URBAN AREA (ha)	COST WITH STORMWATER MANAGEMENT($)	COST OF CONVENTIONAL SYSTEM($)	REMARKS
162	400 000	1 000 000	allowed development 5 years earlier
20	200 000	300 000	
364	400 000	1 300 000	
445	500 000	2 000 000	
28	100 000	300 000	
65	300 000	400 000	
49	150 000	250 000	
1000	3 000 000	2 000 000	gained 16 ha land from floodplain
81	1 000 000	2 000 000	significant overcontrol allowed development
405	4 000 000	4 000 000	gained 35 ha land from floodplain
330	200 000	450 000	
40	50 000	100 000	

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THE GUIDELINES

The Urban Drainage Guidelines comprise the following parts:

(a) Executive Summary for Cabinet
(b) Urban Drainage Design Guidelines
(c) Erosion and Sediment Control
(d) Pollution Control Strategy
(e) Administrative Policies

The following pages are a copy of the Index of the Urban Drainage Design Guidelines.

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URBAN DRAINAGE DESIGN GUIDELINES
MAJOR AND MINOR DRAINAGE SYSTEMS

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URBAN DRAINAGE DESIGN GUIDELINES
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Since many of you are environmental engineers rather than water resources engineers, I would like to discuss briefly two items - definition of major and minor drainage systems and interfaces and methodology.

MAJOR AND MINOR DRAINAGE SYSTEMS - DEFINITION

The minor drainage system comprises swales, street gutters, catchbasins and storm sewers. As detailed later, it accommodates the runoff from the more frequent storms up to the design frequency of the system (e.g. up to once in five years). Properly designed and maintained, it reduces the incidence of inconvenience to both pedestrians and motorists. Flows are conducted away from intersections and pedestrian crossings where ponding would create a nuisance in the summer and a hazard in the winter. Sometimes the minor system is called the "convenience" system or the "incipient" system.

The interface between the minor and major drainage systems is the catchbasins. These should be designed to capture all of the flows up to the intensity of the design frequency (e.g. 1:5 years). But they should also be designed to capture no more than this amount of runoff. When higher intensity runoff is experienced, some of the water will by-pass the catchbasins and will flow down the street.

The major drainage system comprises the natural streams and valleys and the man-made streets, swales, channels and ponds. It is the keystone to good urban drainage, since it should accommodate the runoff from even the least frequent storms such as once in a hundred years and the Regional Storm. Properly designed and constructed, the major system will "essentially eliminate" the risk of loss of life and property damage due to flooding. It must be remembered the major system will exist in a community whether or not it has been planned or designed and whether or

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MAJOR AND MINOR DRAINAGE SYSTEMS - DEFINITION cont'd

not development has been wisely situated with respect to it. Water will obey the law of gravity and flow downhill to seek its lowest level whether buildings or people are in its way or not. Figure 1 illustrates the major and minor drainage systems.

Under the Conservation Authorities Act, we have had regulations in Ontario aimed at reducing the probability of flood damage to structures caused by flooding in the watercourses. The specified level of protection has been the Regional Storm or 1:100 year storm flood levels, whichever is the more stringent. The essence of the dual drainage principle (major and minor drainage systems) is that this same level of protection to structures should also be provided within the minor system. That is, no structure should be flooded from the surface or from the foundation drains by runoff from the Regional or 1:100 year design storm where economically justified.

INTERFACES AND METHODOLOGY

As noted earlier, use of stormwater management and its proper integration into viable urban developments requires a more holistic effort on the part of engineers, planners and biologists than has been past practice. Based on recent experience, however, this is good. In preparing some recent Secondary and Draft Plans, the designers have taken the opportunities provided by stormwater management to create plans that have been declared "exciting" by developers, builders and the residents.

A key feature of all of these plans has been the incorporation of natural waterways, tree stands and valleys, and man-made swales, channels and ponds into continuous park greenways. Since these naturally aesthetic areas are used for water transport,

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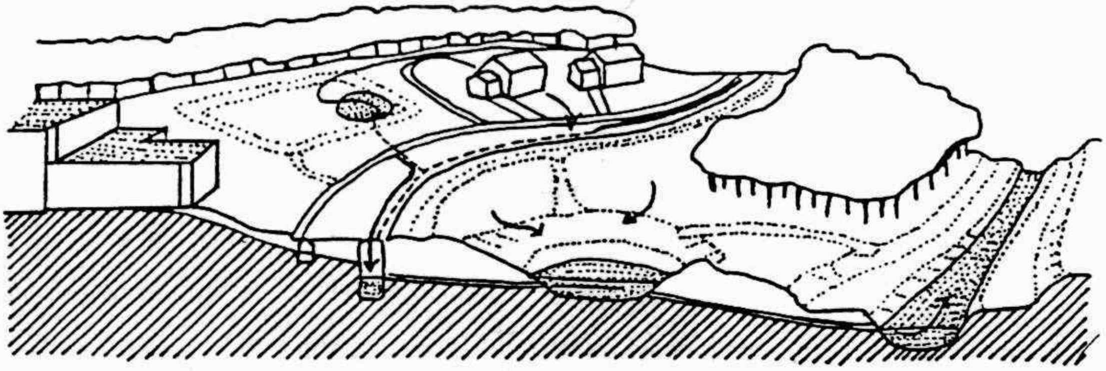


School/Commercial
paved area drains to park or swale
roof top detention

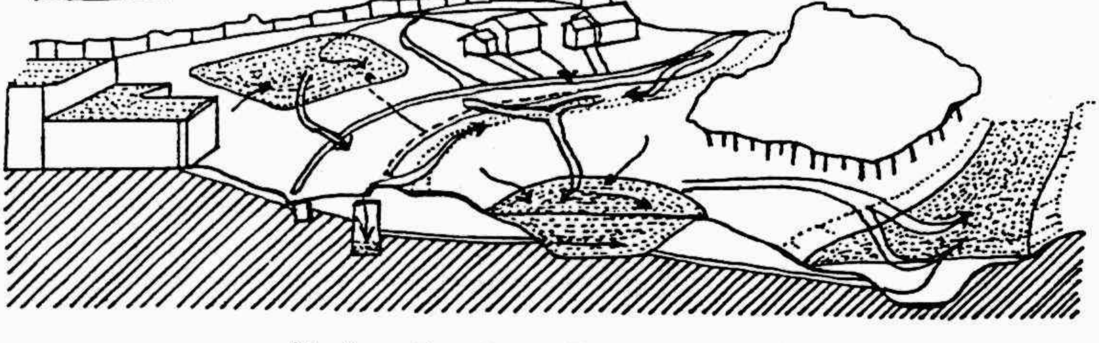
Local Park
field drain or catch basin limits outflow from detention area

Residential
drainage to rear lot swale in optional greenway

Roadway
gutters carry only road drainage to sewer inlet

Flood Plain
on line detention area receives inflow from storm sewers and some local drainage

Minor System Example



School/Commercial
roof top detention
excess flows to major system

Local Park
overflow swale operates for excess flows

Residential
residential lot maintains same drainage paths in all storm conditions

Roadway
carries high level overland flows to suitable outlet

Flood Plain
on line detention area receives overland flow plus minor systems flow. emergency outflow swale releases excess to watercourse

Major System Example

Figure 1 - Major and Minor Systems

retention, detention or even recharge, they conform to the Blue-Green Concept. This name was first suggested in the United States and basically the concept requires that the open spaces provided by Hazard Lands, major drainage systems, valleys and parks be integrated into a continuous Green Belt for the beneficial use of both the people and water transport.

As shown in Figure 2, the first interface between planners, engineers, biologists and economists occurs during preparation of the Watershed Plan by the conservation authority. As far as stormwater management is concerned, a Watershed Plan should define all the flood plains and flood damage centres, areas of erosion and bank instability and the effects of urbanization and SWM measures on quantity and quality in general terms. This information is then used by the municipality when it prepares a Master Drainage Plan for a portion of a larger watershed, or all of a small one (see Figure 3 for methodology). In some cases, floodlines may have to be extended upstream from where the conservation authority left them. Using the opportunity provided by development, the municipality should determine the optimum set of stormwater measures needed for development of the area and indicate approximate sizes and locations of channels and quantity and quality ponds, if these are needed. Ideally, a Master Drainage Plan should be prepared along with a Secondary Plan for an area, but experience shows that some iteration is required. Initially, the MDP will give planners a range of acceptable solutions, which only they can narrow down based on non-hydrologic considerations. Once the planners have decided on the optimal solution, the water resources engineer needs to calculate the final sizes of elements.

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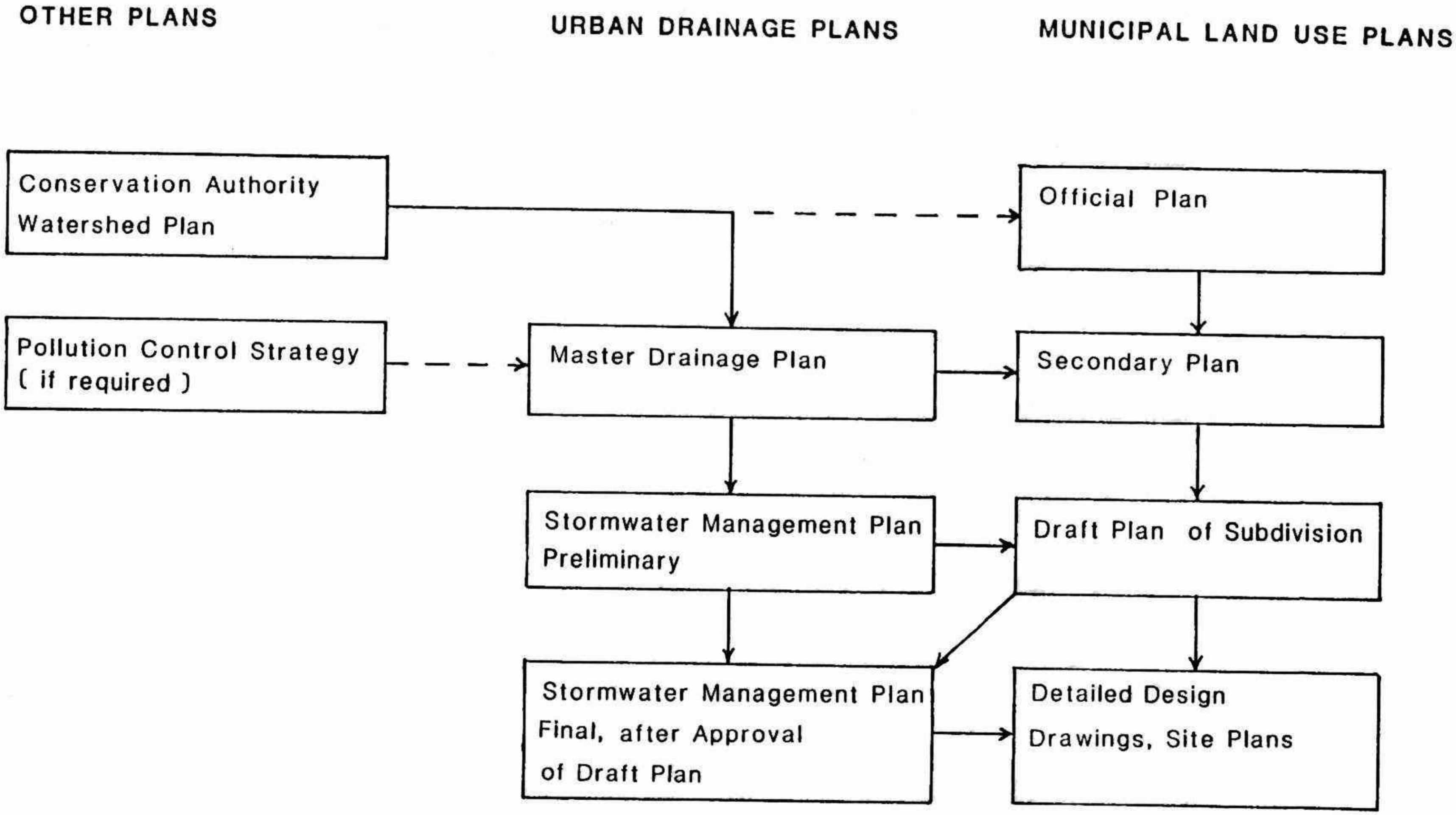
OTHER PLANS
URBAN DRAINAGE PLANS
MUNICIPAL LAND USE PLANS
Conservation Authority Watershed Plan
Official Plan
Pollution Control Strategy (if required)
Master Drainage Plan
Secondary Plan
Stormwater Management Plan Preliminary
Draft Plan of Subdivision
Stormwater Management Plan Final, after Approval of Draft Plan
Detailed Design Drawings, Site Plans

Figure 2 Urban drainage and land use planning

When a Draft Plan is being prepared for a portion of a community, the water resources engineer needs to prepare the preliminary Stormwater Management Plan (SWM Plan). With the street and lot layouts, he will be able to define the extent and directions of the major and minor systems and how the facilities will meet the requirements of the MDP. The requirements for erosion and sediment control should be conceptually investigated.

Only when detailed design drawings (with lot grades, street grades and preliminary storm sewer and catchbasin design) become available is it possible to prepare the Final Stormwater Management Plan Report. The details from this are then incorporated into the detailed design drawings. The SWM Plan Report should document how the works will meet or exceed the applicable requirements of the Master Drainage Plan and Watershed Plan and should detail the erosion and sediment control measures.

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FIGURE 3 - METHODOLOGY FOR MASTER DRAINAGE PLAN STUDIES

PROBLEM DEFINITION

1. Inventory Site and Watershed
   - topography, soils, land use (present and proposed), vegetative cover
   - details on channels, watercourse crossings, culverts. bridges, etc.

2. Preliminary Hydrology and Hydraulics
   - select most appropriate models
   - select design storms
   - simulate pre- and post-development hydrographs
   - define floodlines

3. Define Constraints
   - floodings; history of past floods and storms, flood damage centres, present and future floodlines (with no stormwater management) on watersheds greater than 135 ha
   - erosion; mapping of erosion and valley bank instability on site and downstream, assessment of sensitivity to flow changes, assessent of remedial measures
   - environmental; water quality assessment, environmentally sensitive areas, groundwater recharge or discharge areas
   - institutional; policies and objectives of MOE, MNR, conservation authority, regional and local municipalities
   - economic; (obvious but sometimes forgotten) the aim is to achieve the development at least present value cost or at highest benefit : cost ratio while doing no significant harm to anyone or anything else

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PROBLEM SOLUTION

4. Formulate Alternative Solutions
    - if the hydrologic and hydraulic changes can be handled by the existing system, there is no need to formulate alternative solutions
    - if there are problems or binding constraints, the solutions may include any appropriate set of structural or non-structural measures
    - structural measures include pipe and ditch configurations, dams and weirs, various types of storages, diversion channels, channelizations, diking, dry and wet floodproofing
    - non-structural measures include change of land use, prohibition of flood plain occupancy, use of two zone concept of flood plain management, set backs from valley banks, recreational or low density designation on key parts of groundwater recharge or discharge areas
    - hydrologic and hydraulic analyses to locate and size storage facilities, channels, pipes overland flows

5. Evaluate Alternatives
    - a blend of technical, aesthetic and economic feasiblity
    - quantify, in present value dollar terms, all benefits and costs that can be quantified
    - describe qualitatively all other benefits and costs
    - combine into a benefit cost matrix for comparison of alternatives

6. Report Presentation
    - concise and clear, to aid decision makers and reviewing agencies
    - flood plain maps, computer listings and output, supporting figures

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If the Master Drainage Plan is the link pin between the Conservation Authority's Watershed Plan and municipal drainage plans, then the key to success has to be rigorous definition and evaluation of alternatives. This means that water resource engineers will have to do the hard economic analysis many of you have been accustomed to doing on other engineering projects. Comparing alternatives, we shall have to make sure its an apple vs an apple. Too often have reviewing agencies seen an apple vs an orange vs a banana. If our politicians are to make sound rational decisions, we must provide them with proper data.

EROSION AND SEDIMENT CONTROL GUIDELINES FOR URBAN CONSTRUCTION SITES

by: M.A. Price, P.Eng.
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EROSION AND SEDIMENT CONTROL GUIDELINES FOR URBAN CONSTRUCTION SITES

In 1977, an Urban Drainage Policy Committee was formed under the auspices of the Canada - Ontario Agreement on Great Lakes Water Quality (COA).

The report of the COA Policy Committee "Proposed Model Policies for Urban Drainage Management" was published in 1980 as Canada - Ontario Agreement on Great Lakes Water Quality: Research Report Number 102. As a result of the publication of Report 102 the need for a follow-up implementation committee was recognized and set up towards the end of 1980.

One of the technical guidelines prepared by a sub-committee of the Urban Drainage Implementation Committee is:

EROSION AND SEDIMENT CONTROL FOR URBAN CONSTRUCTION SITES

While runoff from urban areas usually contains suspended sediments through the action of rainfall and water flowing over ground surfaces, the sediment loadings are much greater during the construction period when vegetation is removed and soil is exposed. Areas undergoing development can have a sediment yield of 20 times that of already developed areas and this is about 16 times higher than the upper limit of what is considered tolerable erosion in agricultural losses. High erosion rates from these sites will result in:

- loss of valuable topsoil.
- sedimentation in sewer systems and structures involving expensive removal.
- sedimentation in rivers and lakes affecting water supplies, flood control, fishing, navigation and recreational activities.

Based on the above the Urban Drainage Policy Committee has proposed that erosion and sediment control measures shall be used in the planning and construction of urban developments.

The technical guidelines explain the preparation and implementation of an erosion and sediment control plan which assesses the erosion potential from construction activities and specifies the control measures to mitigate the adverse effects to an acceptable level.

Many people were looking for controls that would limit erosion runoff to a defined specific objective, (eg. x tonnes per hectare). The sub-committee reasoned that as the intent is to request municipalities to inspect the controls used then the sampling and measuring of runoff could not be handled by municipal inspectors.

The guidelines are intended primarily for new subdivision work, however, other types of urban development as well as municipal construction projects can cause erosion and sedimentation problems and should be subject to the same controls.

The approach chosen was to prepare guidelines that would enable a developer, consultant, municipality and contractor to evaluate the erosion potential of their particular site based on the following basic information:

Soil erodibility (k)

Soil Structure or Texture

Slope gradient

Slope length

The soil erodibility has been simplified into three classes but it can still give a good general indication of soil erodibility. The simplified process will also enable the local municipality to readily and easily check a developers evaluation. In the guidelines it has been assumed that the natural vegetation on the site has been removed, the topsoil stockpiled and the sub-soil exposed and/or regraded. The soil erodibility is calculated on the exposed sub-soil.

Once the site has been split into areas of high, medium or low erodibility and the slope gradient and length have been added, then all regions within the construction site can be labelled as being of low, moderate or high erosion potential.

From a shopping list of appropriate erosion and sediment control measures for the construction site the developer can determine which controls to install. As well as for the zones of erosion potential the overall drainage network and spoil piles should be addressed for erosion and sediment control measures.

All areas of a site, even those rated as having low erosion potential, will require some minimum measures which have been called "good housekeeping" practices.

Throughout the guidelines the approach has been to encourage prevention rather than cure therefore emphasis has been placed on protection of exposed surfaces and the control of runoff. Sediment control is to be practised to prevent off-site sedimentation damage. Generally this is achieved by filtering sediment laden flow or impounding to allow settling out of sediment particles.

During construction periods on the site the effectiveness of the controls in place have to be monitored and the proper maintenance carried out. The municipal inspectors are the first line of defence and the success of the entire erosion and sediment control strategy will depend on their diligence. If the control measures chosen are not effective then other methods and controls should be added.

The whole process relies heavily on the individual municipality and because no specific measurable objective has been defined (to avoid costly and time consuming monitoring) there will be a degree of judgement to be exercised.

The lists of methods and techniques given in section B of the guidelines consist of proven and commonly used control measures. They are not exhaustive lists as techniques used for unique situations have not been included. Also one parameter for the lists chosen was that the methods have low construction costs and require unskilled labour to construct and maintain. In selecting the best method, the designer and contractor or site supervisor must consider feasibility, practicality and cost in relation to the goal of effective erosion and sedimentation prevention.

In conclusion I believe that schemes using more than three classes (eg. high, medium, low) imply a level of precision in evaluation that is not matched by control methods in the field. To gain the support of practitioners evaluation schemes should not be too complex and some discretion in choice of methods to meet their goals must be given.

The final stage in the planning and design stage is the preparation of the erosion and sediment control documentation. All relevant information for a new subdivision should be presented in the Storm Water Management Plan. Selection of the appropriate control measures should be based on the methodology outlined in this document. Where existing Master Drainage Plans or Watershed Plans have identified special erosion or sediment control constraints, the Storm Water Management Plan must indicate how the objectives and criteria outlined in these plans have been met.

A developer when applying for draft plan approval, should acknowledge the fact that he intends to meet the objectives and conditions required to control erosion and sedimentation.

The guidelines have been prepared in an easy to read format. The sub-committee believes that education programs are required to convey the material to its potential users and keep them up to date on the state of the art technology. The best way this can be accomplished is by the Provincial Government setting up expertise centres and preparing education and training programs for the users.

PRACTICAL ASPECTS OF STORMWATER MANAGEMENT PLANNING AND DESIGN

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"PRACTICAL ASPECTS OF STORMWATER MANAGEMENT PLANNING & DESIGN"

INTRODUCTION

The intent of this paper is to present a Consulting Engineer's perspective on the developing policies and criteria for implementing Stormwater Management Procedures in Canadian Municipalities. Throughout this seminar, a greal deal of new and useful information relating to drainage system designs and Provincial policies has been presented, and will no doubt be difficult to avoid overlapping comments on what has already been discussed. Nevertheless, the implementation phase of Stormwater Management is an especially critical one, with a heavy burden on developing municipalities to translate policies and criteria into practical standards, designs, and construction.

DRAINAGE DESIGN CRITERIA AND METHODS

The adoption of suitable criteria and standards for drainage designs is of utmost importance. In past, many municipalities relied on open ditch drainage and swale systems, with minimal servicing standards applied to residential areas. This type of drainage was in fact similar to the so-called "blue/green" concept, which is a part of current Stormwater Management technology. The problems that resulted from this drainage design related primarily to unplanned ponding at culverts and in most cases only the minor system was actually designed. Partly because of these problems, and also because of concerns regarding ongoing maintenance costs, design standards were gradually increased to encompass curb and gutter systems, rigorous lot grading requirements, connection of downspouts to storm sewers, and increasing both design rainfall frequencies and runoff coefficients for residential and commercial development.

The result of this process, over the years, has been that storm sewers now represent up to 35% or more of the cost of servicing an acre of residential land. Probably, the benefit-cost relationship of increasing the standards has been low, especially where the design criteria was increased from 2 years to 10 years, for example. Instead of unplanned surface ponding along roadway and ditch systems, flooding problems in basements causing significant structural damage became more prevalent. Downstream impacts including flooding, erosion, and water quality deterioration have been well documented in the literature. It is also not clear that maintenance costs have been significantly reduced over the years.

Corresponding improvements and advances have also taken place in the area of design techniques. The Rational Method, once used exclusively for drainage design purposes, has been supplemented by a variety of computerized hydrograph techniques. The deficiencies of the Rational method have been well documented. These include the fact that it is primarily intended for small area runoff, and provides an estimate of peak flows only. It is an empirical method supported by relatively little calibration or testing on larger drainage areas, on which it has been frequently applied.

In recent years, comprehensive hydrograph techniques have been developed and extensively tested. These have provided the means of analyzing more complex systems of pipe networks and control systems. These design aides have now been standarized to a large extent by some municipalities and research agencies in an attempt to avoid unnecessary discrepancies and conflict in final designs and flows.

Stormwater Management represents a logical response to the above developments. Although the term "Stormwater Management" has often been misused to represent relatively narrow concepts, such as detention systems, in reality Stormwater Management represents a more complete look at the hydrologic cycle in urban areas and its influence on drainage design. A definition of Stormwater Management which is more meaningful is "the planning, analysis and control of urban runoff to satisfy specified objectives".

At the present time a reasonable consensus exists on the objectives to be met. These include the objectives of minimizing unnecessary hazard (major system), provision of an acceptable level of service (minor system), the minimization of onsite and downstream impacts due to drainage development (environment objective), and the assessment of various alternatives in order to achieve the more economical overall drainage system (economic objective).

CURRENT PROVINCIAL POLICIES

Recently proposed provincial policies have concentrated on establishing several basic concepts in municipal drainage and design. These policies include a two-phase planning approach (Master Drainage Plan/Stormwater Management Plan) closely integrated with the land development process. The use of the major/minor system of drainage design is considered fundamental to sound drainage planning, and to achievement of the objectives of a number of provincial agencies. Erosion and Sediment control measures during construction period are emphasized.

The main implementation problems include the establishment of local design criteria in each municipality, the coordination of approvals between the various agencies involved in drainage system development, and the provision of appropriate training and funding facilities for the application of Stormwater Management techniques. Current activities of the Ministries of the Environment and Natural Resources have been designed to assist in resolving some of these problems.

TECHNICAL GUIDELINES

Technical guidelines for Stormwater Management design purposes are now available, and it remains for municipalities to translate these to meet their own requirements and standards. There are a number of important aspects of these guidelines that municipalities should carefully consider.

Computer Models

The use of computer models, as a supplement to traditional design practices, is vital. Comprehensive models, such as the SWMM, have been developed and are available. The advent of micro computers promises municipalities a very cost-effective and efficient method of performing the runoff calculations. While reliance should be placed upon standarized procedures and applications of the current models, the doors should be left open for innovation and flexibility in this area, since in many cases simplified techniques or estimating procedures may be sufficient for the problem at hand.

Hydrologic Parameters

Hydrologic estimates often vary from project-to-project because of the selection of input for parameters hydrograph models. Municipalities should endeavour to standarize those hydrologic parameters relating to infiltration, rainfall, runoff and hydraulics that affect runoff calculations regardless of the model used.

Preferred Types of Facilities

Municipal Drainage Manuals should discuss and comment upon preferred Stormwater Management facilities applicable to that particular municipality, along with examples of operating facilities if available. Currently there are a number of very effective facilities in operation in Ontario, and this experience can be useful if properly described and documented.

On-Site Techniques

While it is desirable to avoid an excessive number of stormwater detention facilities throughout a small drainage basin, the use of on-site techniques to retard runoff on particular lots or developments is a useful technique. Often however, allowance is not made for these facilities on the design of downstream pipe systems and truck services. This tends to reduce the economic incentive for developers to practice on Stormwater Management, and should be considered very carefully by any municipality. There are many occasions where sound on-site drainage facilities can reduce overall costs.

Basement Protection

The issue of basement flooding and surcharge protection has received a lot of attention in recent years. Proposed provincial policies include basements as part of a major system, and attempt to provide a very high level of protection in all areas. The main techniques involved include inlet controls and major/minor system design. However, it should be recognized that most basement flooding problems involve frequent flooding on the order of once every two or three years. Measures designed to provide, say, 25 years protection represent very significant improvements in the situation, and can probably be accommodated quite readily. However, the difficulty of ensuring complete 100 year protection against basement flooding in urban areas is great, since even sump pump systems may fail during an extreme event.

Roadway Systems

Criteria relating to the permissible depths of roadway flooding is important to major/minor system design. Depending upon the roadway cross-section and local topographic conditions, selection of too low a maximum depth may result inability to convey the necessary major system flows. This obviously has implications throughout the design of the subdivision drainage system, and some flexibility should be provided in order to accommodate local conditions. Municipalities should investigate the impact of this criterion using local road section and grades.

Floods during Construction

One aspect of stormwater design which has not received a great deal of attention is that of floods during construction. Heavy rainfall during the construction period can cause significant damage to partially built subdivisions and drainage works. It would be useful to have a discussion of acceptable practice in Drainage Criteria Manuals.

Use of the Regional Storm

Proposed policies stress the use of the 100 year or Regional storm for Stormwater Management purposes. Usually, for small areas, the 100 year storm will govern most designs. However, for some larger areas, the Regional Storm may govern in terms of peak rate or storage volumes. In addition, the amount of computation can be significantly increased in order to determine the controlling factor.

Operation and implementation problems can result from dual criteria. Wherever possible, the use of the Regional storm should be restricted to the definition of floodway and floodplain systems that accommodate runoff from the entire developing area.

Safety & Aesthetics

Although safety and aesthetic issues are a major concern in the implementation of Stormwater Management systems, municipal drainage manuals generally contain very little information with regards to the municipalities accepted practice. A proper discussion of required safety procedures, and a realistic assessment of risk factors would be useful in any drainage manual.

Approvals

The format and procedures for preparing drainage documents and obtaining the necessary approvals should be clearly and succinctly set out in a drainage manual. A good deal of useful work in this regard has been done recently by some municipalities and government agencies, and this work should be reflected in local municipalities manuals.

CONCLUSIONS

The proposed provincial policies and implementation procedures outline a practical approach to Stormwater Management planning and design. A greater emphasis has been placed on municipal responsibility for the planning and approval process for Stormwater Management facilities. The requirement for flexibility in the application of all aspects of Stormwater Management has been emphasized. The treatment of water quality issues appear to be very realistic, in terms of what can be achieved in modern subdivision designs. Finally, the necessary coordination of approval systems has been recognized, and attempts have been made to streamline this. As a result, practioners can look forward to working within this framework, and hope that municipalities would adopt these provisions enthusiastically and proceed to apply them affectively within their own jurisdictions.

URBAN DRAINAGE CONCERNS IN WATERSHED STUDIES

By: D.G. Weatherbe,
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ABSTRACT

Mr. Weatherbe's paper described Ontario's experience in the assessment at a watershed level of water quality and quantity problems arising from urban stormwater.

He presented a number of case histories which illustrated different problem situations arising from runoff inputs and indicated the solutions proposed in each instance.

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Proceedings of the seminar on urban drainage management.
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